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Original Article

A Feasibility Study of an Outpatient Pulmonary Exercise Training Program (Opetp) For Post Covid-19 Patients

Post-COVID Exercise Training

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Abstract

Background: SARS-CoV-2 infection (COVID-19) can cause persistent respiratory, physical, psychological, and multi-system impairments, including breathlessness, fatigue, reduced functional capacity, and poorer quality of life. Exercise training in pulmonary rehabilitation (PR) is vital to prevent further deconditioning after hospital discharge. This study aims to assess the feasibility of a ten-week Outpatient Pulmonary Exercise Training Program (OPETP) for post-COVID-19 patients and evaluate its effects on breathlessness, exercise capacity, functional status, dyspnoea, quality of life, and functional sequelae.

Method: Post-COVID-19 patients referred to OPETP underwent a 10-week program with weekly supervised and home-based aerobic/resistance training. Feasibility was measured by uptake, adherence, tolerability, and safety. Effects were assessed via 6MWT, mMRC, SF-CRQ, and PCFS scores for exercise capacity, dyspnoea, quality of life, and functional sequelae.

Results: Of 118 post-COVID-19 patients referred, 72 (61%) were lost to follow-up and 46 (39%) consented (mean age 55 ± 16 years; 57% male; 59% severe/critical cases). Thirty-two (27%) completed the OPETP. Adherence (≥7 sessions) was achieved by 28– 41% depending on duration; 66% tolerated training. Significant gains included increased 6MWD (369 ± 114 m to 439 ± 122 m), improved dyspnoea (mMRC: –0.8 ± 0.7; $p < 0.001$), better quality of life (SF-CRQ: 75%), and enhanced functional status (PCFS: 66%).

Discussion: Limited pre-referral education reduced PR uptake (61% non-attendance), yet enrolled patients improved 6MWD and quality of life, underscoring benefits of flexible, patient-centred post-COVID rehabilitation.

Conclusion: OPETP is feasible, safe, and may improve breathlessness, fatigue, function, exercise capacity, and quality of life in symptomatic post-COVID-19 patients.

Keywords: Covid-19, exercise program, feasibility, physiotherapy, rehabilitation

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Abbreviations: SARS-CoV-2, Severe Acute Respiratory Syndrome Coronavirus 2; OPETP, Outpatient Pulmonary Exercise Training Program; COVID-19, Coronavirus Disease 2019; PRP, Pulmonary Rehabilitation Program; 6MWT, Six Minute Walk Test; mMRC, Modified Medical Research Council; SF-CRQ, Short Form Chronic Respiratory Disease Questionnaire; PCFS, Post-COVID-19 Functional Status scale; RCT, Randomized Controlled Trial.

Introduction

The COVID-19 pandemic, which rapidly spread across the globe in early 2020, created an unprecedented public health crisis with severe humanitarian and socioeconomic consequences[1]. According to the World Health Organization (WHO), more than seven million deaths had been reported worldwide as of March 9, 2025[2] In addition to its acute morbidity and mortality, many millions of survivors continue to experience post-acute sequelae of COVID-19 (PASC), commonly referred to as post- COVID condition [1,3].

Fatigue and dyspnoea are among the most common and disabling symptoms experienced by people with this condition. this group[4]. While the full scope and duration of these complications remain under investigation, emerging evidence indicates that a considerable proportion of survivors continue to report symptoms for months after the acute phase[1,5]. These sequelae, particularly those affecting pulmonary function, significantly impair quality of life by limiting daily activities, reducing exercise tolerance, and contributing to physical deconditioning. Over time, such limitations may compromise functional independence and predispose individuals to further health decline, highlighting the urgent need for targeted rehabilitation strategies to support recovery and optimise long-term outcomes[1].

Various rehabilitation models have been explored for post-COVID populations, with several studies reporting improvements in exercise capacity, symptom burden, and health-related quality of life following structured interventions[6,7]. However, the design of these programs varies considerably, particularly in terms of duration, frequency, and components. For example, some studies have implemented short-term inpatient rehabilitation of 2–6 weeks[8,9] while others reported centre-based or home-based programs of 8–12 weeks with a mix of supervised and unsupervised sessions[6,10,11].

Importantly, reporting of adherence, exercise tolerability, and post-exertional symptom exacerbation has often been inconsistent across studies, limiting direct comparisons.

Physiotherapy is central to post-COVID rehabilitation, addressing persistent respiratory, functional, and physical impairments. Exercise training, in particular, is a cornerstone of pulmonary rehabilitation (PR) in chronic respiratory diseases, with well-established benefits on exercise tolerance, symptom control, and overall health[12]. While further research is needed to optimise exercise mode, duration, frequency, and intensity in post-COVID populations[13], early intervention cannot be delayed until definitive protocols are developed. Adapting existing PR frameworks with tailored modifications currently offers the most pragmatic approach.

The primary aim of this study was to evaluate the feasibility of a personalised outpatient pulmonary exercise training program (OPETP) for post-COVID-19 patients in a tertiary hospital that managed a large cohort of people with COVID-19. The feasibility focus included enrolment rate, adherence, tolerability, and safety. A secondary aim was to assess preliminary clinical outcomes, thereby contributing to the growing body of evidence on individualised rehabilitation strategies for this population.

Patients and Methods

This prospective observational study employed a convenience sampling method using a single-group design with pre- and post-test evaluations. Ethical approval was obtained from the institutional ethics committee (MREC ID NO: 2021108-10676). All participants provided written informed consent after receiving a full explanation of the study procedures and were informed of their right to withdraw at any time without consequence.

Participants and setting

Participants were recruited from a tertiary hospital in Kuala Lumpur, recognized as one of the major centres for COVID-19 rehabilitation, between January and December 2022. All symptomatic post-COVID-19 patients referred for outpatient PR were screened and enrolled if they met the predefined inclusion criteria. Exclusion criteria included contraindications to exercise as defined by the American College of Sports Medicine (ACSM), the presence of moderate to severe heart disease, a history of severe ischemic or haemorrhagic stroke, neurodegenerative disorders, or severe physical disabilities that could limit participation in exercise[14] Clinical data were extracted from electronic medical records and admission/discharge summaries, including demographics, length of hospitalisation, ICU admission, use of non-invasive ventilation (NIV) or invasive mechanical ventilation (IMV), prescription of long-term oxygen therapy (LTOT) at discharge, and documented comorbidities.

Intervention

The 10-week Outpatient Pulmonary Exercise Training Program comprised a structured combination of aerobic exercises (AE) and resistance exercises (RE), complemented by stretching-based warm-up and cool-down periods **(**Table 1 Protocol of the Outpatient Pulmonary Exercise Training Program**)**. Each week, participants attended one supervised session with a trained pulmonary physiotherapist, lasting approximately 40–60 minutes, and were encouraged to perform an additional four unsupervised home-based sessions to reinforce consistency and promote self-management. Aerobic training intensity was prescribed using the Heart Rate Reserve (HRR) Karvonen method[15], ensuring individualized and safe training loads in line with established exercise prescription guidelines. Resistance training loads were set according to the participant's ability to complete 15–45 repetitions with correct form, with gradual progression guided by tolerance and perceived exertion. The content, dosage, and intensity of the program were adapted from established PR recommendations, as outlined in the Australian Pulmonary Rehabilitation Toolkit[16]. During all exercise sessions, vital signs including heart rate and oxygen saturation were continuously monitored using pulse oximetry. Blood pressure was measured before and after each session to ensure hemodynamic stability. Participants were instructed to rest if oxygen saturation fell below 88% or if they experienced significant adverse symptoms (e.g., chest pain, dizziness, or severe dyspnoea). Perceived exertion and breathlessness were assessed after each exercise bout using the Rate Perceived Exertion; RPE scale (6- 22) and Modified Borg Dyspnoea Scale; MBDS (0-10), respectively, to guide exercise titration.

Outcome measures

Feasibility and some clinical effect outcomes were evaluated based on parameters adapted from a previous study conducted in Switzerland[17]. In addition, challenges commonly encountered by patients attending outpatient PR programs were considered. All outcome measures were assessed at baseline and at the 12-week post- intervention time point.

Primary outcomes (Enrolment rate, Adherence, Tolerability and Safety)

Enrolment rate. Enrolment was further categorized as follows: (i) the show-up rate - defined as the proportion of patients who scheduled a physiotherapy appointment upon receiving a referral, and (ii) the turn-up rate - defined as the proportion who attended their scheduled baseline initial assessment.

Adherence. Adherence was defined as the proportion of attended sessions relative to the total 12 scheduled sessions (10 training sessions from weeks 2–11 and 2 assessment sessions at weeks 1 and 12). Completion was defined as attendance of at least 70% of prescribed sessions or successful participation in the discharge assessment[18,19]. Dropout referred to participants who discontinued the program prematurely due to adverse events or personal reasons. An extended schedule described cases in which participants completed the program despite missed or rescheduled sessions, provided

absences were not consecutive. This framework allowed for flexibility while preserving program integrity.

Tolerability and safety. Tolerability was defined as the ability of participants to perform the prescribed exercises without requiring major adjustments in intensity, duration, or exercise mode. Any modifications made to accommodate symptoms or limitations (e.g., reduced load, shortened exercise duration, or switching exercise modality) were documented to reflect challenges in tolerating the intervention. Safety was ensured through systematic monitoring of adverse events[20,21], defined as any untoward medical occurrence during exercise or in association with the intervention. These included training-related injuries (e.g., musculoskeletal strain) and cardiopulmonary complications (e.g., arrhythmia, oxygen desaturation <88%, chest pain, or presyncope), as well as broader health outcomes such as symptom exacerbations, hospitalisations, or death. Supplemental oxygen was recommended if SpO_2 fell below 88%[22], consistent with established safety thresholds in pulmonary rehabilitation. To guide exercise intensity, subjective measures were applied, with target ranges of MBDS 4–6 for breathlessness and RPE 14–15 for exertion[23]. These thresholds are consistent with international PR recommendations for prescribing moderate-to-vigorous training intensities while ensuring safety and tolerability.

Secondary outcomes (Functional Exercise Capacity, Dyspnoea, Quality of Life and Functional Sequelae)

Functional Exercise Capacity. The Six-Minute Walk Test (6MWT) was conducted to assess functional exercise capacity (6-Minute Walk Distance [6MWD]). Heart rate (baseline, peak, recovery) and nadir SpO_2 were measured using a pulse oximeter, while dyspnoea was assessed with the MBDS. Standardized instructions and encou8ragement were provided by a physiotherapist[24].

Dyspnoea. The degree of disability posed by breathlessness was assessed using the 4-point ordinal Modified Medical Research Council (mMRC) Dyspnea scale, as reported by each patient according to different levels of activity[2526].

Quality of Life. Health-related quality of life was assessed using the self-reported Short Form Chronic Respiratory Questionnaire (SF-CRQ), a validated tool specifically designed to capture patients' perceptions of the impact of chronic respiratory conditions on daily life. It evaluates multiple dimensions of well-being, including dyspnoea, fatigue, emotional function, and mastery (sense of control over the disease)[27].

Functional Sequelae. The perception of COVID-19-specific limitations in daily life was quantified using the self-reported Post-COVID-19 Functional Sequelae (PCFS). The scale was designed to cover the entire range of functional limitations from grade 0, "No functional limitations", to grade 4, "Severe functional limitations", and grade 5, "Death"[28].

Statistical analysis

Descriptive statistics (mean, standard deviation [SD], median, and frequencies) were used to summarise patient demographics, baseline clinical characteristics, and feasibility outcomes (recruitment, adherence, tolerability, and safety). Functional exercise capacity, assessed by the 6MWD, was expressed both as a percentage of predicted norms and relative to the lower limit of normal (LLN). The minimal important difference (MID) for 6MWD was considered to range between 25–33 m, based on established evidence [29,30]. Adherence rates were compared using McNemar's test, which is appropriate for analysing paired nominal data (e.g., ≥70% adherence vs. non-adherence) and allows assessment of within-subject changes in categorical outcomes. Pre- and post-intervention scores, including six-month follow-up data for clinical outcomes (6MWT, mMRC, SF- CRQ, and PCFS), were analysed according to data distribution using either the paired t- test (for normally distributed data) or the Wilcoxon signed rank test (for non-parametric data). Statistical significance was set at a two-sided $p < 0.05$. All analyses were conducted using IBM SPSS Statistics[31].

Table 1 Protocol of the Outpatient Pulmonary Exercise Training Program

Exercise type	Prescription
Stretching	Warm-up and cool-down, 4 minutes each
Aerobic exercise	
Mode	Cycling and walking
Intensity/ Load	40% to 80% of HRR MBDS (4 and 6), SpO2 ≥ 90%, RPE (13-14)
Frequency and duration	once supervised, four home sessions, 15-30minutes gradual progression
Resistance exercise	
Mode	Dynamic isokinetic machine, quadriceps bench, sandbags
Load	Weekly progression
Frequency	once supervised, four home sessions, 3 series 15 repetitions each

Illustration of the training dose and intensity used obtained as such; moderate-intensity activity as using 40% > HRR < 60%, and vigorous-intensity activity as using HRR > 60%[17] HRR = Heart Rate Reserved; MBDS = Modified Borg Dyspnoea Scale; RPE= Rate Perceived Exertion.

Table 2 Characteristics of the Study Participants (n=46)

Variables		n (%)
Gender		
	Female (%)	20 (43)
	Male (%)	26 (57)
Smoking history		
	Smokers	5 (11)
	Ex-smokers	6 (13)
	Non-smokers	35 (76)
Pre-existing Comorbidities		
	Hypertension	26 (57)
	Dyslipidaemia	18 (39)
	Diabetes Mellitus	15 (32)
	Cardiovascular disease	6 (13)
	Obstructive sleep apnoea	4 (9)
	Lung disease	9 (20)

	Chronic renal disease	3 (7)
	Cancer	3 (7)
Respiratory therapy		
	NIV	23 (50)
	Room air	21 (46)
	Ventilator	2 (4)
	LTOT	1 (2)

Data is presented as n (%). Abbreviations: n = number; NIV = Non-Invasive Ventilation; LTOT = Long Term Oxygen Therapy.

Table 3 Changes in Rehabilitation Outcomes Following Exercise Training in the 6MWD measurements

n=32		Baseline (Mean ± SD)	Re-assessment (Mean ± SD)
	Peak HR (bpm, % pred HRmax)	118 ± 17 (72 ± 12)	120 ± 15 (73 ± 10)
	Nadir SpO2 (%)	91 ± 2	92 ± 5

Data is presented as Mean ± SD. Abbreviations: bpm = beat per minute, HR = heart rate, s = seconds; SD = standard deviation; SpO2 = percutaneous oxygen saturation; 6MWD = six-minute walk distance.

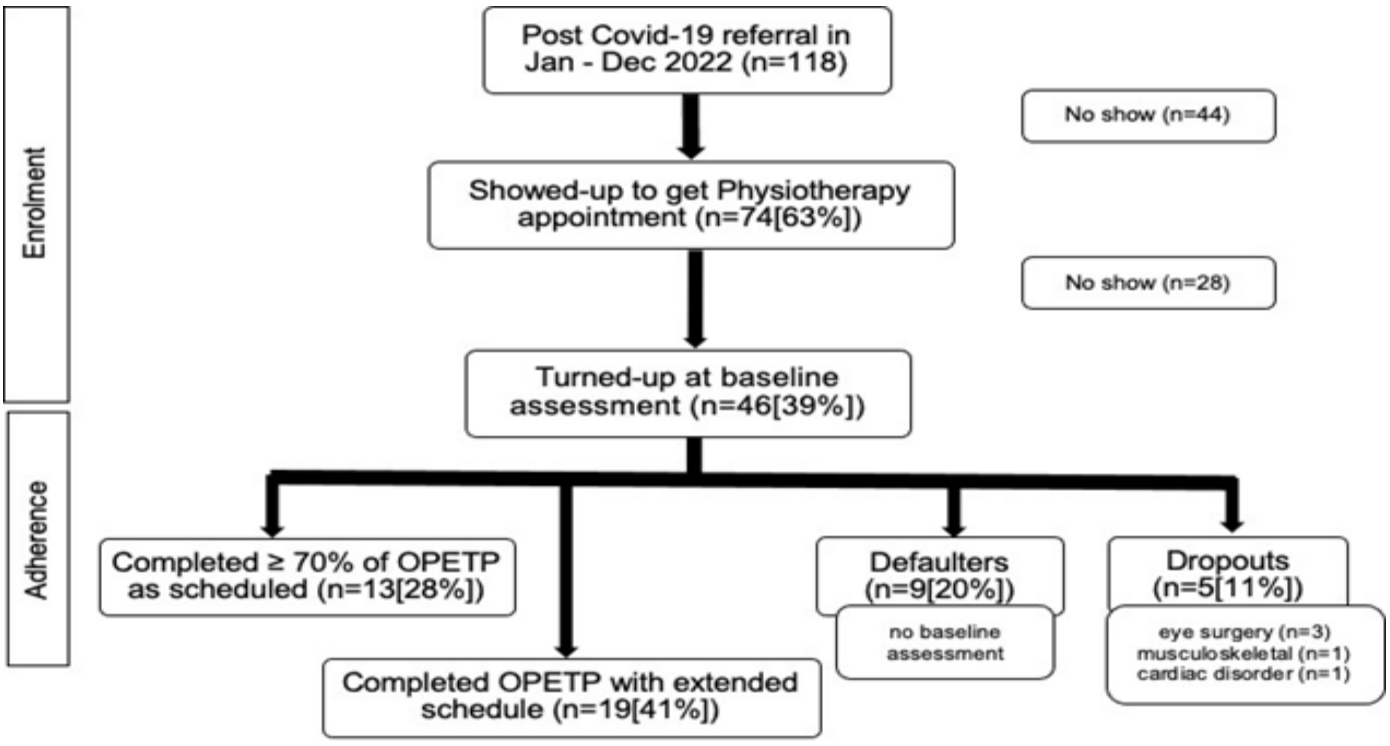

Figure 1 Flow-chart of patient recruitment

Figure 1

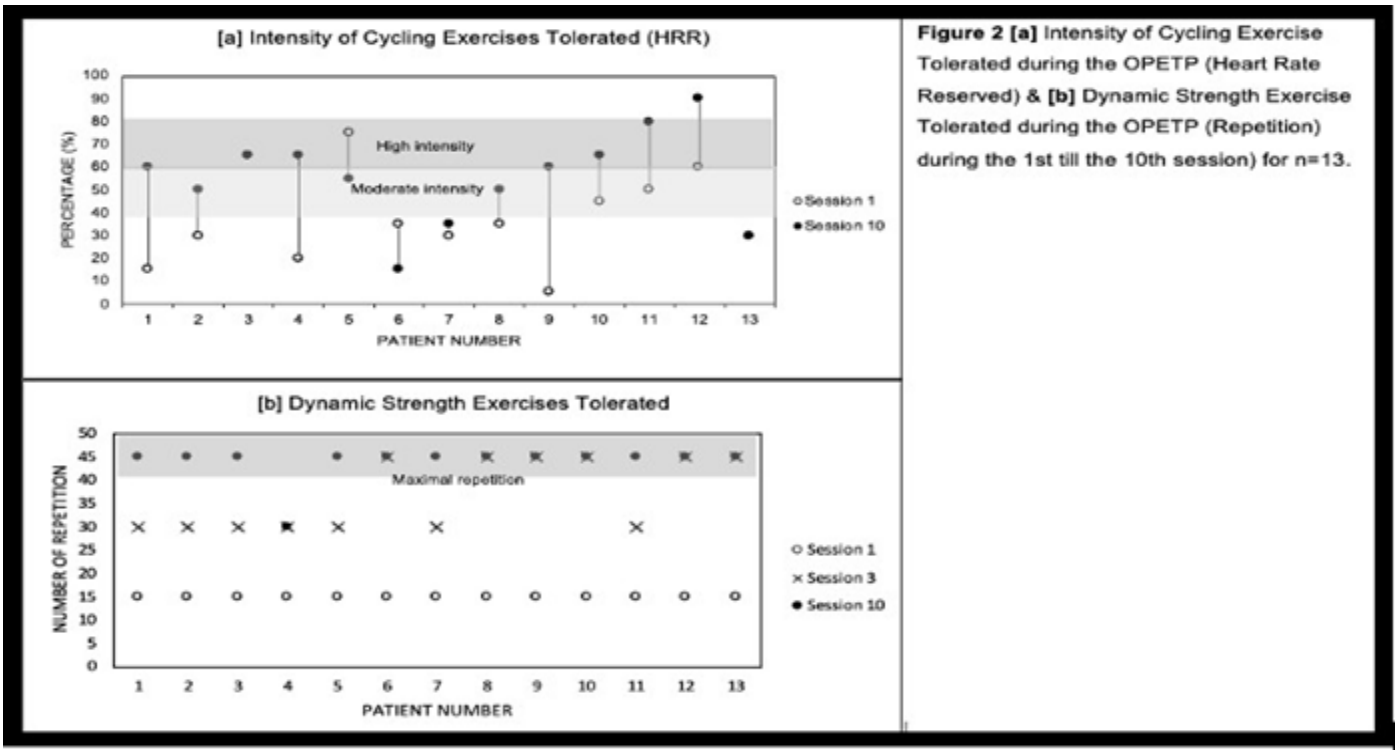

Figure 2 [a] Intensity of Cycling Exercise Tolerated during the OPETP (Heart Rate Reserved) & **[b]** Dynamic Strength Exercise Tolerated during the OPETP (Repetition) during the 1st till the 10th session) for n=13.

Figure 2

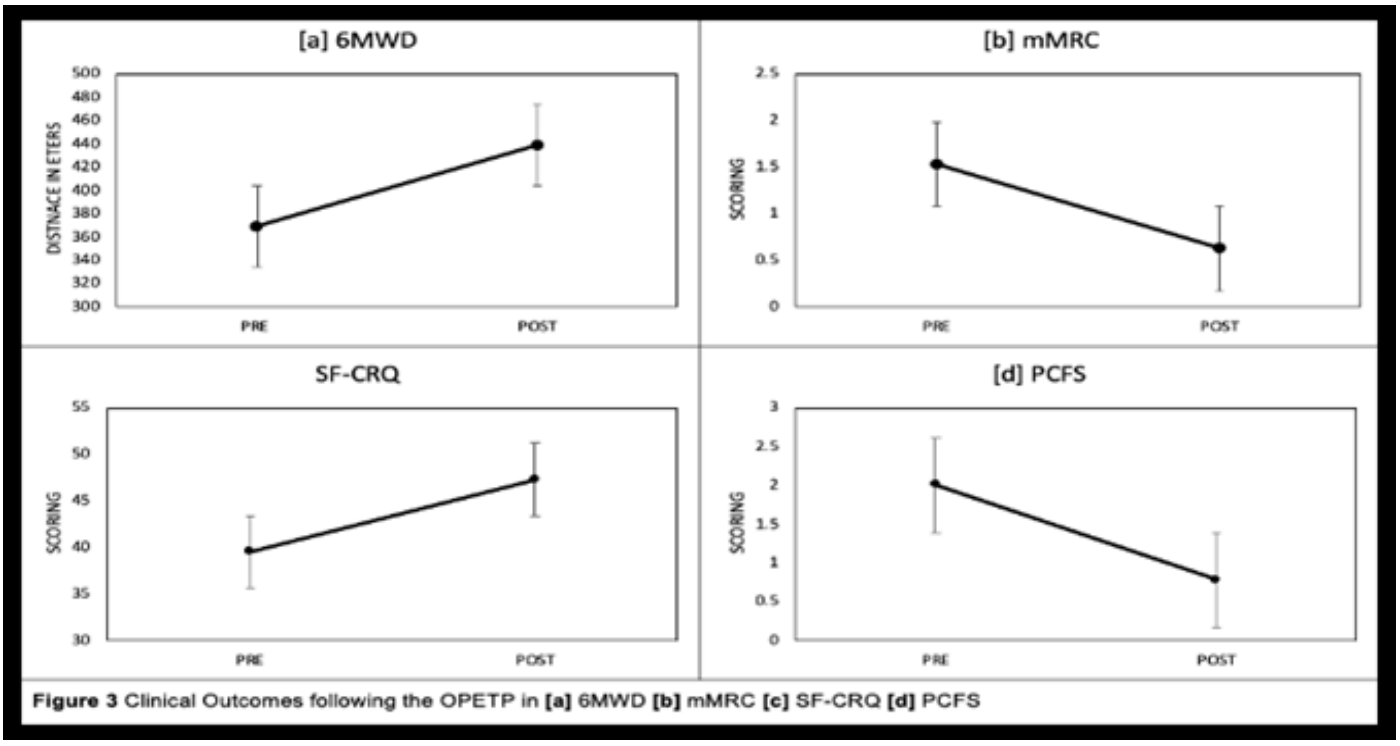

Figure 3 Clinical Outcomes following the OPETP in **[a]** 6MWD **[b]** mMRC **[c]** SF-CRQ **[d]** PCFS

Figure 3

Results

The characteristics of the 46 participants are shown in **(**Table 2 Characteristics of the Study Participants (n=46). The mean ± SD age of the participants was 55 ± 16 years and the majority (26 [57%]) were male. Of the 46 participants, 19 (41%) had a mild to moderate course of COVID-19, while 27 (59%) experienced severe to critical illness, classified according to the World Health Organization COVID-19 severity criteria[32]. The average hospitalisation duration was 8 ± 21 days, with 6 patients requiring ICU admission. Upon admission, 23 (50%) required non-invasive ventilation and 2 (4%) mechanical ventilation. One (2%) participant was discharged with long term oxygen therapy. Hypertension 26 (57%), Dyslipidaemia 18 (39%) and Diabetes Mellites 15 (32%) were reported to be the most common pre-existing co-morbidities among these participants.

Primary outcomes

Enrolment Of the 118 post-COVID-19 patients referred to the OPETP, 74 (63%)

- "showed-up", responded to the referral and scheduled an appointment, and 46 (39%) - "turned-up", subsequently attended the baseline assessment **(**Figure 1**)**. However, attrition was noted, with 44 patients not scheduling an appointment following referral and 28 not attending their baseline assessment after an appointment scheduled.

Adherence Regarding adherence to the OPETP (Figure 1**)**, 13 (28%) participants completed ≥ 70% of the OPETP within the 12-week program duration and 19 (41%) completed ≥ 70% of the OPETP with an extended schedule (i.e. up to 6 months). Nine (20%) participants defaulted after a few sessions of exercise training, while 5 (11%) dropped out immediately after baseline assessment, resulting in loss of follow-up and absence of post-assessment data in 14 (31%) participants. Of the nine participants who defaulted, one attended only a single session, four attended between three to six sessions, and the remaining four completed seven sessions but did not return for post-training assessment.

Tolerability and safety Of the 41 (89%) participants who participated in the exercise training, 27 (66%) tolerated the OPETP exercise training as originally prescribed. Of these participants, 11 (41%) were those adherent to the OPETP, 12 (44%) were from the extended schedule, and four (15%) were the defaulters. Figure 2**[a]** illustrates the predicted peak heart rate percentage (%) using the Karvonen method during the first and tenth sessions of bike cycling exercise training (aerobic exercise) among participants who adhered to the OPETP (n = 13), highlighting the increase in prescribed exercise intensity over time; the mean values for both sessions are represented by the linear line. By the end of the programme, participants demonstrated improved exercise tolerance, progressing from initial low-to-moderate intensity (30 – 60%) to tolerating moderate-to-high intensity levels (60 – 90%). Ten patients tolerated the mode and target of OPETP as recommended, whereas three required some modifications. Two participants (15%) from the adherent group were unable to tolerate the OPETP prescription; one was unable to engage in bike cycling due to left knee pain. This participant had a left bow leg deformity. Another participant reported recurrent back pain while walking on the treadmill. Figure 2**[b]** presents the dynamic strength training component, where resistance exercises (chest press and shoulder press) were performed using machines. All participants performed the exercises at a standardized tempo, completing 15 repetitions per set. From the third session onward, the prescription was progressed to three sets (45 repetitions) for the remainder of the programme. At this stage, seven participants (54%) successfully achieved and maintained the three-set target, while one participant (8%) remained unable to complete the prescribed repetitions due to persistent fatigue and weakness throughout the programme.

Secondary outcomes

Only 32 (27%) participants completed the training in OPETP with an evaluable end-of-training assessment. Wilcoxon signed-rank tests showed that the treatment led to statistically significant changes in all scores shown in Figure 3 **of [a] 6MWD, [b] mMRC, [c] SF-CRQ** and **[d] PCFS** (all $p < 0.05$). The participants walked a mean of 369 ± 114m during the baseline 6MWT and 439 ± 122m during re-assessment with a magnitude change of 70 ± 8m **(**Figure 3 **[a]).** This study shows that both those in the adherent group and extended duration program were able to improve their 6MWD, increased with a mean of 92 ± 51m. (Table 3 Changes in Rehabilitation Outcomes Following Exercise Training in the 6MWD measurements) presents a comparison of physiological and subjective parameters recorded during the 6MWT at baseline versus re-assessment. The data demonstrates a modest increase in peak heart rate and a slight improvement in the percentage of predicted maximal heart rate achieved. In addition, nadir oxygen saturation levels showed a mild elevation, while participants reported reduced dyspnoea scores. A notable reduction in rest duration was

also observed. A mean difference of 0.8 ± 0.7 was observed in dyspnoea scores, with baseline values recorded at 1.5 ± 0.7 and post- intervention reassessment at 0.6 ± 0.6 points **(**Figure 3**[b]).** Nineteen participants (59%) reported improvements in dyspnoea, while 13 (41%) continued to experience persistent symptoms despite completing the exercise training sessions.

Figure 3 **[c]** shows the mean quality of life score was 39.5 ± 10.6 at baseline and

47.0 ± 7.0 at reassessment, out of a maximum total score of 58 on the SF-CRQ. The magnitude of change between baseline and re-assessment measurement was $p < 0.001$. Twenty-four (75%) participants claimed an improvement in their SF-CRQ while seven reported a decline in quality of life and one recorded no change.

At baseline, participants reported a mean PCFS **(**Figure 3**[d])** score of 2 ± 1, indicating slight to moderate functional limitations. Following completion of the OPETP, the mean score improved to 0.8 ± 0.75, corresponding to no to only negligible limitations, thereby reflecting meaningful recovery in daily functional status. At re-assessment, 21 participants (66%) reported improvement in functional sequelae, eight (25%) reported no change from baseline, and three (9%) reported worsening functional limitations. Notably, those who reported deterioration were among the non-adherent group and unable to tolerate the exercise training. However, this study found no statistically significant differences in mean 6MWD, SF-CRQ, PCFS, or mMRC scores between those who were adherent versus those who were non-adherent.

Discussion

This study evaluated the feasibility, adherence, and clinical impact of a 12-week Outpatient Pulmonary Exercise Training Programme for post-COVID-19 patients. The key findings are threefold. First, the programme was feasible and generally well tolerated**,** with two-thirds of participants completing training sessions as prescribed without modification. Second, clinically meaningful improvements were observed in functional exercise capacity**,** with 78% of participants achieving a ≥30 m increase in 6MWD (range: 35–220 m), alongside favourable changes in cardiovascular and respiratory responses during the 6MWT. Third, substantial gains were also reported in patient-reported outcomes**,** with 75% of participants noting improvements in health-related quality of life, including reduced fatigue, improved emotional well-being, and enhanced functional independence. Our OPETP was delivered over 12 weeks in an outpatient setting, combining one supervised session per week with a structured home exercise component. This format differs from shorter inpatient models by emphasising sustained engagement in the community and balancing supervision with self-management. These distinctions highlight the need for standardised, evidence-based rehabilitation protocols that can be adapted to the diverse clinical needs and recovery trajectories of post-COVID patients.

Adherence emerged as an important determinant of recovery trajectory. Among participants who completed the OPETP as scheduled, 77% demonstrated clinically significant functional improvements, whereas those requiring extended training (16–20 weeks) achieved comparable benefits but at a slower pace. This suggests that while a standard 12-week programme is effective for many patients, an extended duration may be necessary for individuals with more severe baseline impairment, comorbidities, or delayed recovery—an observation not reported in any other studies to our knowledge at this time. Notably, dyspnoea relief was greater in the extended group (68%) compared to the scheduled group (46%), underscoring the value of tailoring rehabilitation timelines to patient-specific needs. This may be explained by evidence suggesting that post-COVID-19 patients with more severe baseline impairment, comorbidities, or delayed physiological recovery often experience slower improvements in respiratory mechanics, muscle strength, and exercise tolerance. Prior studies in chronic respiratory disease populations have also shown that longer or more intensive rehabilitation yields greater symptomatic relief, particularly

when deconditioning and persistent inflammation are present. Therefore, extended programmes may allow sufficient time to consolidate physiological adaptations, improve exercise capacity, and ultimately translate into greater dyspnoea relief for this patient population[4,5,33].

Despite positive outcomes, adherence challenges were evident. Of 46 participants enrolled, only 13 (28%) adhered fully to the 12-week programme. Non-adherence was more common in extended-duration participants, who defaulted or discontinued sessions, often due to fatigue, comorbidities, or competing commitments. Five participants discontinued due to exercise intolerance, frequently linked to underlying conditions such as bronchiectasis, atrial fibrillation, or obstructive sleep apnoea. These findings reflect the complex interplay between medical, psychosocial, and logistical factors influencing programme uptake and persistence. Importantly, while improvements in 6MWD, dyspnoea, and quality of life were observed in both adherent and extended-duration participants, no statistically significant differences were found between adherent and non- adherent groups in mean 6MWD, mMRC, SF-CRQ, or PCFS scores. This indicates that non-adherence did not necessarily equate to absence of improvement, although the pace and completeness of recovery differed. To our knowledge, this observation has not been reported in similar post-COVID rehabilitation studies, highlighting its novelty and potential relevance for future programme design.

Our findings align with previous research demonstrating the benefits of exercise rehabilitation in post-COVID-19 populations. In a Swiss feasibility study, Betschart et al. reported that only 8 of 12 patients completed 16 physiotherapist-guided sessions despite 48 being initially assessed, and further noted that only 10 of 12 participants tolerated the prescribed exercise, with 9 completing the programme at the intended intensity[17]. These results reinforce the need for structured monitoring of exercise tolerance and attrition. Centre-based rehabilitation models, more common in the literature[6,10,11,12] often report higher adherence due to closer supervision and reduced logistical barriers.

For example, a quasi-experimental study found that 80 of 121 referrals were excluded or refused participation, leaving only 26 in the final analysis[34] while an RCT demonstrated that a 90-day exercise training rehabilitation programme significantly reduced dyspnoea in patients with post-COVID Acute Respiratory Distress Syndrome; ARDS[35]. Similar functional gains were also reported in a six-week PR programme in older adults[36]], and in an eight-week supervised multicomponent exercise programme, which improved fatigue, dyspnoea, and functional status[37]. Collectively, these studies suggest that flexible, supervised interventions can achieve clinically relevant improvements, although adherence and tolerability remain common challenges.

This study also highlights systemic challenges within a referral-based model. Of 118 patients referred to physiotherapy, 61% did not engage with the programme at all, most without explanation and many uncontactable. Such attrition mirrors barriers identified in other post-COVID rehabilitation studies, including scheduling delays, lack of early patient education, and psychosocial barriers to attendance[38]. These factors underscore the need for earlier engagement—ideally at the point of referral—to increase patient awareness, motivation, and readiness for rehabilitation. The observed improvements in dyspnoea, functional capacity, and quality of life suggest that OPETP can support recovery from persistent post-COVID-19 symptoms. Importantly, our data indicate that a standard 12-week programme may be sufficient for many patients**,** but others benefit from extended rehabilitation to achieve comparable outcomes. The ability to identify those who may need an extended duration of a program remains challenging at present, with limited guidance available. For this reason, a flexible, patient-centred approach – adjusting programme length and intensity according to illness severity, comorbidities, and baseline functional status is therefore essential.

Limitations and future direction

These findings should be interpreted cautiously. One of the main challenges was the time constraints imposed by the lockdown and pandemic which restricted timely recruitment and follow-up for the overall time allocated to this study. In addition, as a single-centre study with a modest sample size, the findings cannot be generalised to broader populations. Natural recovery trajectories, return to daily activities, and the easing of pandemic restrictions may also have influenced the observed improvements, making it difficult to attribute all changes solely to the intervention. Future randomised controlled trials with larger cohorts are warranted to determine the optimal programme parameters, including training duration and intensity, and to validate the role of individualised assessment tools in tailoring rehabilitation to patient needs.

Conclusion

In summary, this study demonstrates that the OPETP is feasible, well tolerated, and beneficial for symptomatic post-COVID-19 patients, leading to improvements in exercise capacity, dyspnoea, quality of life, and functional status. Importantly, the findings suggest that physiotherapists and rehabilitation specialists can adapt established PR protocols used for chronic lung diseases to treat post-COVID-19 patients, with adaptations reflecting available resources and clinician expertise. Nonetheless, adherence remains a key challenge, and it remains unclear to what extent observed improvements reflect the intervention versus natural recovery. Future multicentre studies with larger cohorts and appropriate control groups are warranted to confirm these findings, determine optimal programme parameters, and support broader implementation in post-COVID-19 care.

Ethics approval ID

This study was registered with the Medical Research Ethics Committee of PPUM (MREC ID NO: 2021108-10676).

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Declaration of competing interest

None

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Conflict of interest statement

The author(s) declare that there is no conflict of interest regarding the publication of this manuscript.

References

1. Gray K, Gills B. Introduction: post-COVID transformations. In: Kissler S, editor. Post-COVID transformations. London: Routledge; 2022. p. 1-11.
2. Nopp S, Moik F, Klok FA, Gattinger D, Petrovic M, Vonbank K, et al. Outpatient pulmonary rehabilitation in patients with long COVID improves exercise capacity, functional status, dyspnea, fatigue, and quality of life. Respiration. 2022;101(6):593- 601.
3. Talotta R. Impaired VEGF-A-mediated neurovascular crosstalk induced by SARS- CoV-2 spike protein: a potential hypothesis explaining long COVID-19 symptoms and COVID-19 vaccine side effects? Microorganisms. 2022;10(12):2452.
4. Fernández-de-Las-Peñas C, Palacios-Cena D, Gomez-Mayordomo V, Palacios-Cena M, Rodriguez-Jimenez J, de-la-Llave-Rincón AI, et al. Fatigue and dyspnoea as main persistent post-COVID-19 symptoms in previously hospitalized patients: related functional limitations and disability. Respiration. 2022;101(2):132-

41.

5. Aytür YK, Köseoglu BF, Taşkıran ÖÖ, Gökkaya NK, Delialioğlu SÜ, Tur BS, et al. Pulmonary rehabilitation principles in SARS-CoV-2 infection (COVID-19): revised guideline for the acute, subacute, and post-COVID-19 rehabilitation. Turk J Phys Med Rehabil. 2021;67(2):129-45.
6. Gloeckl R, Leitl D, Jarosch I, Schneeberger T, Nell C, Stenzel N, et al. Benefits of pulmonary rehabilitation in COVID-19: a prospective observational cohort study. ERJ Open Res. 2021;7(2):00081-2021.
7. Pouliopoulou DV, Macdermid JC, Saunders E, Peters S, Brunton L, Miller E, et al. Rehabilitation interventions for physical capacity and quality of life in adults with post–COVID-19 condition: a systematic review and meta-analysis. JAMA Netw Open. 2023;6(9):e2333838.
8. Tozato C, Ferreira BF, Dalavina JP, Molinari CV, Alves VL. Cardiopulmonary rehabilitation in post-COVID-19 patients: case series. Rev Bras Ter Intensiva. 2021;33(2):167-71.
9. Maniscalco M, Fuschillo S, Ambrosino P, Martucci M, Papa A, Matera MG, et al. Preexisting cardiorespiratory comorbidity does not preclude the success of multidisciplinary rehabilitation in post-COVID-19 patients. Respir Med. 2021;184:106470.
10. Foged F, Rasmussen IE, Budde JB, Rasmussen RS, Rasmussen V, Lyngbæk M, et al. Fidelity, tolerability and safety of acute high-intensity interval training after hospitalisation for COVID-19: a randomised cross-over trial. BMJ Open Sport Exerc Med. 2021;7(3):e001038.
11. Al Chikhanie Y, Veale D, Schoeffler M, Pepin JL, Verges S, Hérengt F. Effectiveness of pulmonary rehabilitation in COVID-19 respiratory failure patients post-ICU. Respir Physiol Neurobiol. 2021;287:103639.
12. Gloeckl R, Leitl D, Schneeberger T, Jarosch I, Koczulla AR. Rehabilitative interventions in patients with persistent post COVID-19 symptoms: a review of recent advances and future perspectives. Eur Arch Psychiatry Clin Neurosci. 2024;274(8):1819-28.
13. Cattadori G, Di Marco S, Baravelli M, Picozzi A, Ambrosio G. Exercise training in post-COVID-19 patients: the need for a multifactorial protocol for a multifactorial pathophysiology. J Clin Med. 2022;11(8):2228.
14. American College of Sports Medicine, editor. ACSM's health-related physical fitness assessment manual. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2013.
15. Ignaszewski M, Lau B, Wong S, Isserow S. The science of exercise prescription: Martti Karvonen and his contributions. BCMJ. 2017;59(1):38-41.
16. Mc Namara R. The pulmonary rehabilitation toolkit. Aust J
17. Betschart M, Rezek S, Unger I, Beyer S, Gisi D, Shannon H, et al. Feasibility of an outpatient training program after COVID-19. Int J Environ Res Public Health. 2021;18(8):3978.
18. Holland AE, Cox NS, Houchen-Wolloff L, Rochester CL, Garvey C, ZuWallack R, et al. Defining modern pulmonary rehabilitation: an official American Thoracic Society workshop report. Ann Am Thorac Soc. 2021;18(5):e12-29.
19. Steiner M, McMillan V, Lowe D, Holzhauer-Barrie J, Mortier K, Riordan J, et al. Pulmonary rehabilitation: an exercise in improvement. National COPD Audit Programme: clinical and organisational audits of pulmonary rehabilitation services in England and Wales. London: RCP; 2017.

20. McGregor G, Powell R, Finnegan S, Nichols S, Underwood M. Exercise rehabilitation programmes for pulmonary hypertension: a systematic review of intervention components and reporting quality. BMJ Open Sport Exerc Med. 2018;4(1):e000400.

21. Garvey C, Bayles MP, Hamm LF, Hill K, Holland A, Limberg TM, et al. Pulmonary rehabilitation exercise prescription in chronic obstructive pulmonary disease: review of selected guidelines: an official statement from the American Association of Cardiovascular and Pulmonary Rehabilitation. J Cardiopulm Rehabil Prev. 2016;36(2):75-83.

22. Pretto JJ, Roebuck T, Beckert L, Hamilton G. Clinical use of pulse oximetry: official guidelines from the Thoracic Society of Australia and New Zealand. Respirology. 2014;19(1):38-46.

23. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14(5):377-81.

24. Holland AE, Spruit MA, Troosters T, Puhan MA, Pepin V, Saey D, et al. An official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. Eur Respir J. 2014;44(6):1428-46.

25. Williams N. The MRC breathlessness scale. Occup Med (Lond). 2017;67(6):496-7.

26. Mahler DA, Witek TJ Jr. The MCID of the transition dyspnea index is a total score of one unit. COPD. 2005;2(1):99-103.

27. Tsai CL, Hodder RV, Page JH, Cydulka RK, Rowe BH, Camargo CA Jr. The short-form chronic respiratory disease questionnaire was a valid, reliable, and responsive quality-of-life instrument in acute exacerbations of chronic obstructive pulmonary disease. J Clin Epidemiol. 2008;61(5):489-97.

28. Klok FA, Boon GJ, Barco S, Endres M, Geelhoed JM, Knauss S, et al. The Post-COVID-19 Functional Status scale: a tool to measure functional status over time after COVID-19. Eur Respir J. 2020;56(1):2001494.

29. Chan KS, Pfoh ER, Denehy L, Elliott D, Holland AE, Dinglas VD, et al. Construct validity and minimal important difference of 6-minute walk distance in survivors of acute respiratory failure. Chest. 2015;147(5):1316-26.

30. Rikli RE, Jones CJ. The reliability and validity of a 6-minute walk test as a measure of physical endurance in older adults. J Aging Phys Act. 1998;6(4):363-75.

31. IBM Corp. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp; 2020.

32. World Health Organization. Expanding our understanding of post COVID-19 condition: report of a WHO webinar, 9 February 2021. Geneva: World Health Organization; 2021.

33. Liu Z, Hu B, Zeng T, You C, Li N, Liu Y, et al. A comparative cohort study of post-COVID-19 conditions based on physical examination records in China. EBioMedicine. 2025;112:105423.

34. Araújo BT, Barros AE, Nunes DT, Remígio de Aguiar MI, Mastroianni VW, de Souza JA, et al. Effects of continuous aerobic training associated with resistance training on maximal and submaximal exercise tolerance, fatigue, and quality of life of patients post-COVID-19. Physiother Res Int. 2023;28(1):e1972.

35. Romanet C, Wormser J, Fels A, Lucas P, Prudat C, Sacco E, et al. Effectiveness of exercise training on the dyspnoea of individuals with long COVID: a randomised controlled multicentre trial. Ann Phys Rehabil Med. 2023;66(5):101765.

36. Liu X, Li P, Xiao L, Lu Y, Li N, Wang Z, et al. Effects of home-based prescribed pulmonary exercise by patients with chronic obstructive pulmonary disease: study protocol for a randomized controlled trial. Trials. 2019;20(1):41.

37. Jimeno-Almazán A, Pallarés JG, Buendía-Romero Á, Martínez-Cava A, Franco-López F, Sánchez-Alcaraz Martínez BJ, et al. Post-COVID-19 syndrome and the potential benefits of exercise. Int J Environ Res Public Health. 2021;18(10):5329.

38. Hayton C, Clark A, Olive S, Browne P, Galey P, Knights E, et al. Barriers to pulmonary rehabilitation: characteristics that predict patient attendance and adherence. Respir Med. 2013;107(3):401-7.